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# Dual Use
# of Distributed Remote Sensing Satellites



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# *Dual Use of Distributed Remote Sensing Satellites*

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# DUAL USE OF DISTRIBUTED REMOTE SENSING SATELLITES

by

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## ABSTRACT

Satellites can serve both defense and the environment, simultaneously monitoring preparations for aggression, the environment, pollution, and natural disasters. These applications have been discussed extensively in international meetings, which have produced specific projects for cooperation and growing acceptance of dual-use concepts.

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The 1991 Erice International Seminars on Planetary Emergencies afforded extensive discussion of distributed remote sensing (DRS) from constellations of small satellites for global awareness and ecological measurements.[1] That generated support for a "First Step" to define the dual uses of DRS for defense and the environment.[2] Several international meetings refined the concept, defined the World Laboratory's Global Environmental Monitoring (GEM) project, and explored the dual uses of DRS for strategic defense as part of a global protective system (GPS).[3] These discussions have identified a number of projects in which collaboration could be mutually beneficial. This report discusses the sensors, satellites, constellations, and cooperation required.

## I. SATELLITES, SENSORS, AND CONSTELLATIONS.

The last decade's work on compact satellites for missile defense has advanced technology, improved performance, and reduced cost to the point where it appears practical to make intermediate-resolution measurements of defense and ecological phenomena from the constellations of satellites needed for global coverage.[4] The requirements for effective dual use are covered in "Distributed Remote Sensing for Defense and the Environment," [5] discussed at the 1991 Erice Seminars on Planetary Emergencies.[6] It indicates the sensors required for defense, meteorological, climate, and pollution measurements; estimates the constellations needed; and describes the passive and active sensors available for moving target indication and high-resolution imaging for global warning of aggression.

The technologies, concepts, and requirements for DRS[7] can be combined into the performance map shown in the attached figure, which gives the space and time resolutions available from various sensors and constellations. Sensors that now could be deployed on small satellites range from hundred-meter resolution radar measurements of cloud measurement, weather prediction, traffic assessment, and crop monitoring to few meter synthetic aperture radar (SAR), infrared, or visible measurements for tactical intelligence and mobile target detection. Laser ranging and detection from efficient diode-pumped systems could permit prompt damage assessment and chemical weapon detection and assessment.

DRS is also applicable to environmental measurements such as those of the U.S. Earth Observing System (EOS), where it could permit the resumption of lapsed climate measurements and test needed new sensors such as lidars and SARs.[8] Two new concepts are of particular interest. The first is a constellation of visible-IR sensor satellites to provide frequent revisit times for prompt information on the local status of agriculture. The second is a constellation of satellites with moderate resolution visible and IR sensors to provide continuous surveillance for prompt, global news information.[9] Each has obvious defensive applications.

A single satellite such as Landsat in a polar sun-synchronous orbit gives coverage about every 16 days, which is not frequent enough for either farmers or news organizations. But a constellation of 16 satellites would give coverage every day, which could be adequate for agribusiness, and 64 satellites would give near-continuous viewing of every point on the globe. Using more efficient orbits inclined over the areas of interest would reduce constellation sizes by factors of 2-3 to 20-30 satellites. Thus, the constellations required appear practical. The sensors could be quite small. Each could weigh a few kilograms and consume only a few watts of power. Thus, they would not necessarily require a dedicated satellite; they could be added to any satellite in a relevant orbit. The bandwidths required to report their observations locally and archive them globally would typically be only a few hundred kilobits per second, the order of the excess initial capacity on communication constellations, which would appear to be attractive hosts.

Studies have also indicated that DRS could efficiently contribute to both the gathering of background and target phenomenology and to the provision of the warning and metrics needed for the Strategic Defense Initiative (SDI). Proposed dual-use applications of SDI satellites and sensors are discussed further below. These studies have also recognized the potential importance of DRS in addressing growing proliferation problems, for which constant observation and spectral flexibility can in some cases be more important than high spatial resolution.

## II. OPPORTUNITIES AND ISSUES.

DRS capabilities have been discussed with, and are reflected in, reports and programs of a number of U.S. agencies, including NASA, the Department of Defense (DoD), and the Department of Energy (DOE).[10] These interactions have identified useful options, but they have also exposed problems—some institutional, some programmatic. The EOS Engineering Review endorsed DRS for its innovative ideas for advanced versions of EOS sensors, but raised concerns about the maturity of designs, the availability of new components, and the long-term calibration of novel sensors. That has produced ideas for resuming lapsed measurements, but not a program for the development of advanced passive and active sensors.

In studying improved Landsat, Commerce and Space Council were influenced by concepts for advanced imaging sensors for global news and simple sensors with spectral flexibility for monitoring agriculture, but only designs were available for interagency review. Prototype data are now available, but DRS has fallen behind agency decision cycles. In DoD applications, DRS failed to penetrate initial studies of global surveillance and mobile targets. DRS concepts were excluded—in part because initial concepts lacked the all-weather and moving-target-indication capabilities of more-developed radars. None of these problems is lethal, but the time to overcome them and get DRS back into the mainstream efforts in defense and civil efforts is short.

DOE national laboratories have been key players in advancing DRS, which offers an opening, now formalized in space policy, to apply their strengths in the physical sciences to important and challenging national problems and to make their capabilities more accessible to other agencies and industry. The DOE is attempting to establish a national consortium involving government and industry. It could evolve naturally from the National Technology Initiative and lever off several decades of sensor and satellite development for verification, arms control, and defense, and extensive skills and facilities for advanced computing, information processing, hardened electronics, and materials to rapidly assess the emerging international market for DRS.

## III. RUSSIA AND THE OTHER FORMER SOVIET REPUBLICS (FSRs).

Russia and FSRs have impressive capabilities in boosters, sensors, and satellites. That has created options and problems. Perhaps the most awkward is the proposal to use demilitarized FSR boosters as launchers for GEM satellites. That is an important issue, because of its potential for generating hard currency, but it is a divisive issue, because it cuts across U.S. domestic commercial space policy. It would appear appropriate for the FSRs to use converted boosters to launch a number of GEM satellites, perhaps with U.S. assistance in integration and data handling.

This suggestion represents a departure from the 1991 discussions at Erice, where it was argued that advances in DRS could only be made with miniaturized sensors and satellites. The FSRs' ability to convert boosters, sensors, and satellites—and the favorable economics of doing so—indicate that the FSRs could make an effective contribution with current sensors and launchers.[11] They could provide useful data from visible and IR sensors and SARs for comparison with the data from other sources. The highest payoff would appear to be in the exchange of information on measurements, their interpretation, and collaboration on the design of sensors. Limited U.S. support could perhaps have the greatest leverage in those areas. It would be useful to define better the dual use of satellites, aircraft, and ground stations and the archiving of their data.

The FSRs have expressed interest in flying advanced U.S. sensors, but that could require further relaxation of tensions. It might be more practical to go through a period of several years in which the U.S. and FSRs fly their own sensors with their own boosters, while working out means of exchanging data as a step towards greater cooperation. That would also provide time to investigate the extent to which military assets and data bases could be made available to the GEM project, which is an appropriate vehicle for coordinating internal and international FSR activities.

The ecological problems in the FSRs are staggering. The GEM project appears appropriate and feasible for them. It could clearly contribute to many, but some important problems involve ground contamination by chemical or radiological materials. DRS can remotely sense gross material migrations through vegetation, emissivity, and reflectivity changes, but current capabilities may not be sufficiently direct to replace ground measurements. Collaboration on advanced sensors could be particularly useful in this area. Meanwhile, the FSRs could be well served by improving ground and aircraft measurements and using satellites for data readout and transmission. It will take time to absorb all of the data presented at the Dubna meeting and refine joint efforts. This *Proceedings* is an important step toward effective communication and cooperation.

## IV. STRATEGIC DEFENSE.

Dual-use applications of DRS for strategic defense were discussed at length at the 1992 Erice Seminars on Planetary Emergencies,[12,13] winning wide support from scientific participants. Much work is needed to define simple sensors that can provide quality data for targets, backgrounds, and warning,[14] but if political support can be generated, joint U.S.-Russia efforts in dual uses of SDI assets could provide a framework for the extension of DRS to a range of sensors, a larger number of participants, the integration of ground, air, and space observations, and the archiving of results into a combined data base accessible to all friendly nations.

Dual-use of defensive sensors is only a part of DRS, and SDI's satellites are only one set of possible vehicles. They are not all that numerous. Even "brilliant eyes" would offer only a few tens of platforms, which is not all that well matched to global applications. Moreover, there could be problems in adding simple sensors to already expensive satellites, which might impact the survivability of the primary sensors. But SDI satellites do provide a backbone for deployment, which could evolve in time, and miniature science and technology integration (MSTI) satellites for the development of SDI sensors provide an early and inexpensive vehicle for jointly developing and cross-calibrating sensors. The joint definition and design of dual-use sensors for MSTI could lead into the more demanding joint design efforts needed for the U.S.-Russia joint early warning center from the Washington Summit, which will require similar integration efforts.

## V. SUMMARY.

Acceptance for DRS is growing in the U.S., Russia, and other FSRs among scientific, political, and military leaders. It has a number of viable scientific and commercial applications. It also has promising dual-use applications, through which DRS could provide essential services to SDI. That would serve as both a test and implementation of promising dual-use applications, which could convince other potential supporters, to which DRS now appears immature and fragmented. Legitimate, defined scientific projects, which have already gained legitimacy within the FSRs, could serve as the basis for improved communication and cooperation. Thus, the dual use of strategic defense satellites could grow rapidly from a bilateral initiative into a multilateral—potentially global effort, which could address defense and environmental problems on more relevant time scales than conventional approaches.

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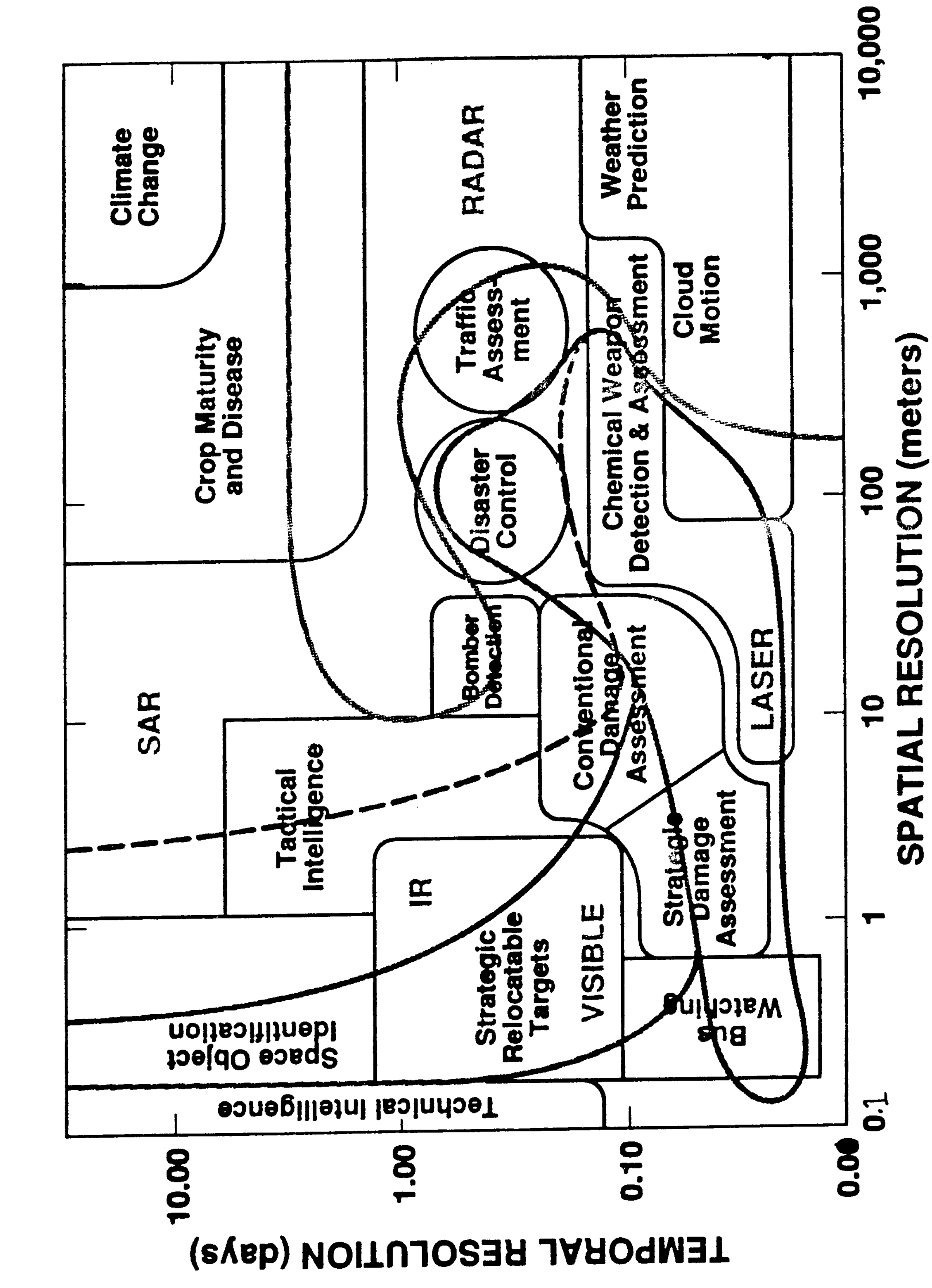

TEMPORAL RESOLUTION (days)
10.00
1.00
0.10
0.01
SPATIAL RESOLUTION (meters)
0.1
1
10
100
1,000
10,000
Climate Change
Crop Maturity and Disease
RADAR
Weather Prediction
Traffic Assess-ment
Disaster Control
Chemical Weapon Detection & Assessment
Cloud Motion
SAR
Bomber Detection
Conventional Damage Assessment
LASER
Tactical Intelligence
IR
Strategic Damage Assessment
Strategic Relocatable Targets
VISIBLE
Bus Watching
Space Object Identification
Technical Intelligence